

**STICKY TRAP CATCH OF WINTERFORM AND  
SUMMERFORM PEAR PSYLLA  
(HOMOPTERA: PSYLLIDAE)  
OVER NON-ORCHARD HABITATS**

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*Abstract.*—We monitored movement by winterform and summerform pear psylla, *Cacopsylla pyricola* Foerster, into non-orchard habitats using large sticky traps placed at various distances from a source pear orchard. Psylla counts were large on traps near the orchard, rapidly decreased between 5 and 20 meters from the orchard, and then flattened out at larger distances (20–120 m). Summerform counts were female-biased; fall winterform counts showed no bias in sex ratio. Models of the form: trap catch =  $\exp(B_0 + B_1 [\text{meters}]^c)$ , and trap catch =  $B_0 + B_1(1/\text{meters})$  were fitted to the data, where meters is distance the trap was from the source orchard, and  $c$  is a constant. The reciprocal model fit the data better than did the exponential models. Counts of winterforms during spring reentry were described by the reciprocal model or by a linear model. Catch on the back-side of traps was the same as that on the orchard-side of traps. Trap catch did not vary with compass direction except during spring, when counts were largest on traps to the south of the source orchard; a second orchard, directly south of the source orchard, may have contributed to this effect.

*Key Words.*—Insecta, *Cacopsylla pyricola*, dispersal, sampling, modeling

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Pear psylla, *Cacopsylla pyricola* Foerster, is a monophagous pest of pears in many temperate fruit growing regions. The species occurs as two seasonal morphs that differ in life histories (Oldfield 1970). The overwintering morph (winterform) undergoes a reproductive diapause in fall, at which time large numbers disperse from the orchard and overwinter on other tree fruit species (Purcell & Suslow 1984, Horton et al. 1994) or in non-orchard habitats (Hodgson & Mustafa 1984). Reentry into pear orchards occurs the following spring as temperatures warm (Fye 1983, Horton et al. 1992). The summerform morph is lighter in color and smaller than the winterform morph. Dispersal characteristics of summerforms are not well understood. Some studies have shown that this morph is sedentary, in that insects are not common outside the pear orchard (Purcell & Suslow 1984); other studies have shown that large numbers disperse from the orchard, particularly when psylla densities are high (Fye 1983).

Dispersal by pear psylla has consequences for management, affecting the spread of pesticide resistance (Follet et al. 1985), timing of control efforts (Westigard & Zwick 1972), and possibly the success, if implemented, of fall control programs (Krysan 1990, Horton et al. 1992). Virtually all of our information about psylla movement concerns dispersal into other orchard habitats (Hodgson & Mustafa 1984, Purcell & Suslow 1984, Horton et al. 1994). In this study, we monitored

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psylla movement into non-orchard habitats using large sticky traps. We sampled at several times of the year, allowing us to compare behavior of the fall emigrating population, the spring colonizing population, and emigrating summerforms. We monitored sex ratio of emigrants to determine whether one sex might be more dispersive than the other. Finally, we modeled the relationship between trap catch and distance from the source orchard. The distance/catch data were compared to a number of different models, including a model that is consistent with a diffusion process (Taylor 1978, Rudd & Gandour 1984). The diffusion model represents the most simple description of dispersal (Kareiva 1982), and consistent deviation from the model or agreement with the model should provide information about pear psylla behavior.

#### MATERIAL AND METHODS

*Sampling Methods.*—The study area circumscribed an isolated pear orchard located at the southern mouth of the Yakima canyon, 15 km north of Yakima, Washington (Fig. 1). The surrounding habitat is composed of cropland or native rangeland (Fig. 1). The traps were bordered to the east and west by steep hillsides (entrance to the canyon), to the north by the canyon mouth, and to the south by fallow fields or native vegetation. The nearest commercial pear is approximately 1 km south of the study area. The source pear orchard is approximately 0.5 ha in size and composed of 10–20 year-old ‘Bartlett’ pear. An organic pest control program was implemented for the duration of the study.

Clear barrier traps were composed of PVC pipe and clear plastic sheeting used in construction of sails for wind surfers. Paired wooden posts were sunk into the ground to a depth of 0.5–1 m, and the traps attached between these frames. The clear portion of the trap was 0.92 by 1.84 m in size; the upper edge of the trap was approximately 2.5 m above ground. The trap surface was made sticky by coating it with a thin layer of STP Oil Treatment (Krysan & Horton 1991). Traps were set out in four directions (Fig. 1), with the face of each trap perpendicular to the pear orchard. Sampling was done over the following intervals: fall winterforms (Oct.–Dec. 1990 and 1991); spring winterforms (Feb.–May 1991, Jan.–April 1992); summerforms (May–Sept. 1991). Traps were replaced at approximately biweekly intervals. Field-collected traps were taken to the laboratory where psylla were counted. Because of low counts, data for all but the Oct.–Dec. 1990 winterforms were analyzed for the summed catch over the trapping intervals. Data for the Oct.–Dec. 1990 winterforms were analyzed for each sampling interval. Both sides of the trap were coated with STP except during the 1990 intervals. Sex ratios of trapped insects were determined for the 1990 samples and for the summerform samples.

*Statistical Analyses.*—A number of models have been fitted to distance-density samples. Models are often of the form:

$$\text{density} = \exp(B_0 + B_1[\text{distance}^c]),$$

where  $c$  varies between  $-1$  and  $4$  (Taylor 1978). We fitted four models of this form:  $c = 2, 1, 0.5, -1$ . We included a reciprocal model of the form:

$$\text{density} = B_0 + B_1[1/\text{distance}],$$

as none of the exponential models described the data (see Results). The exponential

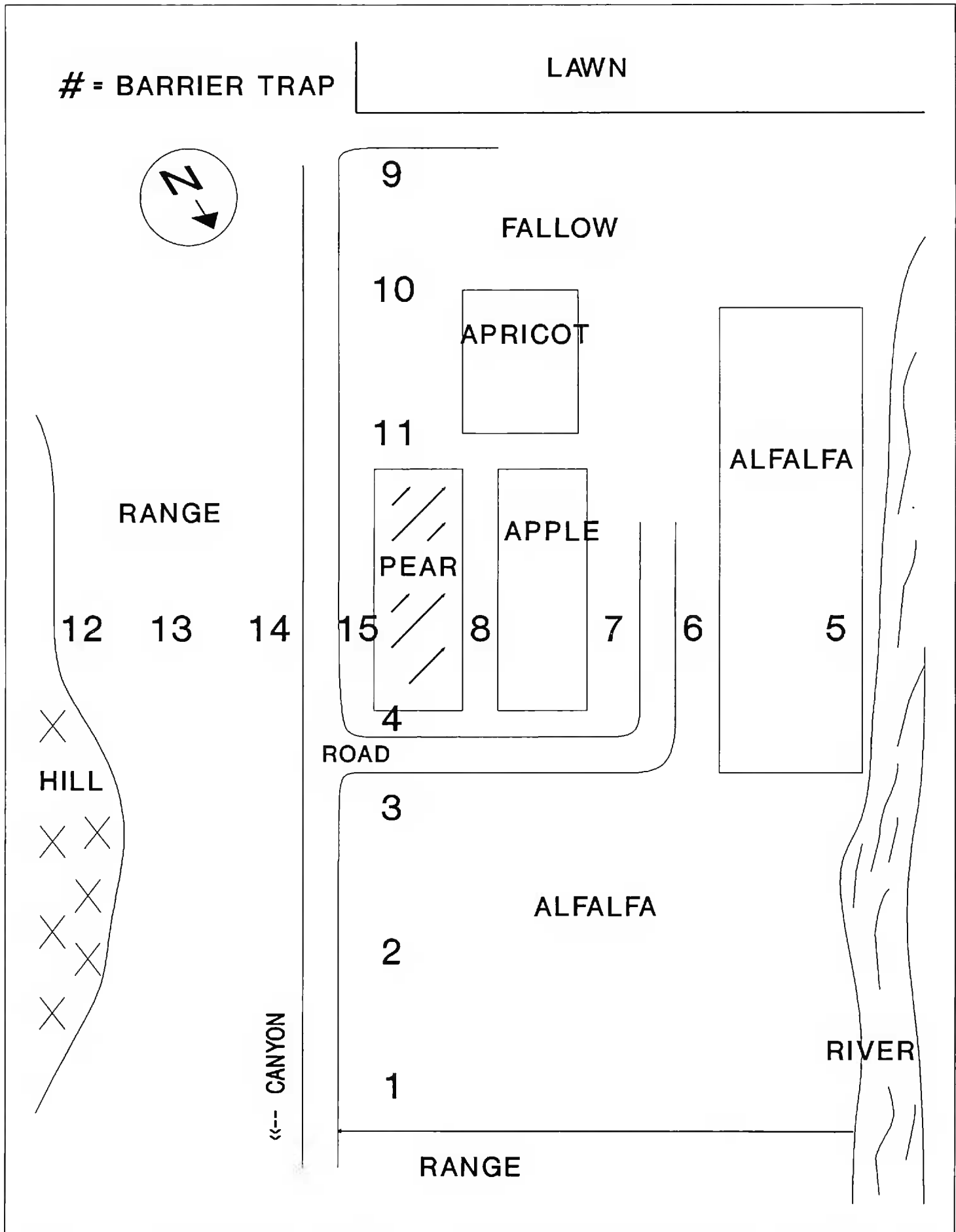


Figure 1. Trap placement at isolated pear orchard, 15 km north of Yakima, Washington. Trap locations designated by numbers (map not to scale). Trap distance from source pear—#1: 113 m; #2: 75 m; #3: 38 m; #4: 8 m; #5: 73 m; #6: 48 m; #7: 28 m; #8: 1.8 m; #9: 92 m; #10: 51 m; #11: 9 m; #12: 116 m; #13: 81 m; #14: 41 m; #15: 6 m.

models were fitted using PROC NLIN in SAS (SAS 1987), and the reciprocal model was fitted in PROC REG (SAS 1987). Trap catch was expressed as a fraction of that occurring on the trap closest to the orchard (1.8 m; Fig. 1); i.e., relative catch = (catch on trap *i*/catch on the 1.8 m trap). This transformation standardized

trap catch to between 0 and 1, and allowed us to compare different sampling intervals and the two morphotypes (there was large variation in numbers trapped among sampling intervals). Slopes and intercepts were compared among intervals and between morphotypes with analysis of covariance (ANCOVA). Analyses were done in PROC GLM (SAS 1987).

We also compared observations and regression models with a "dilution" curve. This model assumes that, for a constant sized trap, trap catch of an evenly dispersing population halves with each doubling of the distance from a point source due to dilution or "thinning out" (Wadley & Wolfenbarger 1944; Wadley 1957); i.e., expected catch =  $(1.8)(1/\text{meters})$ . The curve was again standardized by expressing catch relative to that at the closest trap (1.8 m). The dilution curve was compared with results from the regression equations by placing 95% confidence bands around the regression lines (Neter et al. 1985, 154) and noting whether the dilution curve fell outside the bands.

To compare compass directions in trap catch, residuals from the regressions were calculated and entered into a one-way analysis of variance (ANOVA). Variation among compass directions in size of residuals suggests that trap catch was higher in some directions than others after adjusting catch for distance.

Finally, we estimated mean distance dispersed by trapped insects (see Fletcher 1974; Southwood 1978: 334). Trap distance was categorized into 1 of 4 ranges: 0–30 m, 30–60 m, 60–90 m, 90–120 m. We then estimated proportion ( $p_i$ ) of psylla in the  $i^{\text{th}}$  ( $i = 1$  to 4) annulus (Fletcher 1974):

$$p_i = [(n_i/m_i)(r_{2i}^2 - r_{1i}^2)] / \sum_i [(n_i/m_i)(r_{2i}^2 - r_{1i}^2)],$$

where  $n_i$  is number of psylla trapped in the  $i^{\text{th}}$  annulus,  $m_i$  is number of traps in the  $i^{\text{th}}$  annulus,  $r_{1i}$  is the inner radius of the  $i^{\text{th}}$  annulus, and  $r_{2i}$  is the outer radius of the  $i^{\text{th}}$  annulus. The mean distance dispersed ( $d$ ) by trapped psylla is:

$$d = \sum_i (p_i)(0.5)(r_{1i} + r_{2i}).$$

This estimate refers only to trapped insects and ignores that proportion of the population that dispersed beyond the study area (Fletcher 1974), and we used these estimates only to provide crude comparisons among sampling intervals and between morphotypes in distances flown by trapped psylla.

## RESULTS

The reciprocal model consistently outperformed the exponential models for emigrating winterforms and summerforms (Table 1; Fig. 2), and much of the remaining discussion will be restricted to the reciprocal model. The "dilution" model fell outside the 95% confidence intervals for the reciprocal model in all sampling intervals, particularly at longer trap distances (Figs. 3–5). The best fits for the reciprocal model occurred for intervals in which large numbers of psylla were trapped (i.e., 1–14 Nov 1990; Fig. 3). The reciprocal model did not fit counts obtained on the back-side of traps for the 1991 winterform data ( $P = 0.81$ ; Fig. 4, open symbols). A linear model also did not fit ( $P = 0.30$ ). A linear model fit the data for the back-side of traps for the summerform data ( $P = 0.005$ ; Fig. 5,

Table 1. Residual mean squares and parameter estimates for five models fitted to fall winterform and summerform trap catch (Figs. 2–5).  $y$ —daily trap catch (relative to catch on the 1.8 m trap);  $m$ —meters.

Model	Residual MS	$B_0$	$B_1$
Winterforms, 19–31 October 1990			
$y = \exp(B_0 + B_1 m^2)$	0.966	0.069	-0.0164
$y = \exp(B_0 + B_1 m^{0.5})$	0.748	0.685	-0.535
$y = \exp(B_0 + B_1 m)$	1.038	0.287	-0.153
$y = \exp(B_0 + B_1 m^{-1})$	1.508	-1.926	3.577
$y = B_0 + B_1 m^{-1}$	0.644	0.083	1.794
Winterforms, 1–14 November 1990			
$y = \exp(B_0 + B_1 m^2)$	1.139	0.012	-0.0151
$y = \exp(B_0 + B_1 m^{0.5})$	0.488	0.767	-0.588
$y = \exp(B_0 + B_1 m)$	0.806	0.259	-0.151
$y = \exp(B_0 + B_1 m^{-1})$	1.442	-1.695	3.139
$y = B_0 + B_1 m^{-1}$	0.433	0.107	1.709
Winterforms, 15 November–17 December 1990			
$y = \exp(B_0 + B_1 m^2)$	7.582	0.015	-0.0083
$y = \exp(B_0 + B_1 m^{0.5})$	2.122	0.084	-0.180
$y = \exp(B_0 + B_1 m)$	3.065	-0.292	-0.016
$y = \exp(B_0 + B_1 m^{-1})$	2.155	-1.238	2.305
$y = B_0 + B_1 m^{-1}$	1.789	0.261	1.428
Winterforms, 11 September–6 November 1991			
$y = \exp(B_0 + B_1 m^2)$	4.796	0.075	-0.0177
$y = \exp(B_0 + B_1 m^{0.5})$	4.835	0.782	-0.601
$y = \exp(B_0 + B_1 m)$	4.922	0.331	-0.171
$y = \exp(B_0 + B_1 m^{-1})$	3.502	-1.736	3.213
$y = B_0 + B_1 m^{-1}$	3.261	0.134	1.608
Summerforms, 9 May–11 September 1991			
$y = \exp(B_0 + B_1 m^2)$	1.168	0.031	-0.0207
$y = \exp(B_0 + B_1 m^{0.5})$	0.806	1.014	-0.770
$y = \exp(B_0 + B_1 m)$	0.957	0.349	-0.200
$y = \exp(B_0 + B_1 m^{-1})$	0.649	-2.198	4.044
$y = B_0 + B_1 m^{-1}$	0.322	0.057	1.731

open symbols), whereas the reciprocal model fit poorly ( $P = 0.06$ ;  $r^2 = 0.25$ ). There was no significant difference between numbers caught on the back-side and orchard-side of traps for either morphotype (Figs. 4–5; paired sample  $t$ -tests:  $P > 0.10$ ).

Slope coefficients did not differ among the four sampling intervals for fall winterforms (Figs. 3–4; ANCOVA –  $F = 0.37$ ;  $df = 3,40$ ;  $P = 0.77$ ; common slope coefficient = 1.63 [SE = 0.127]). Intercept terms, which estimate trap catch at long distances, did differ among the four intervals ( $F = 3.1$ ;  $df = 3,43$ ;  $P = 0.039$ ), indicating that heights of the four curves were not identical (see Figs. 3–4). The largest difference appeared to be between the late November–December, 1990 interval (Fig. 3, bottom panel) and the other sampling intervals. Slope coefficients were similar between summerform and winterform morphs ( $F = 0.38$ ;  $df = 4,53$ ;  $P = 0.82$ ; common slope = 1.65 [SE = 0.101]). The intercept term was

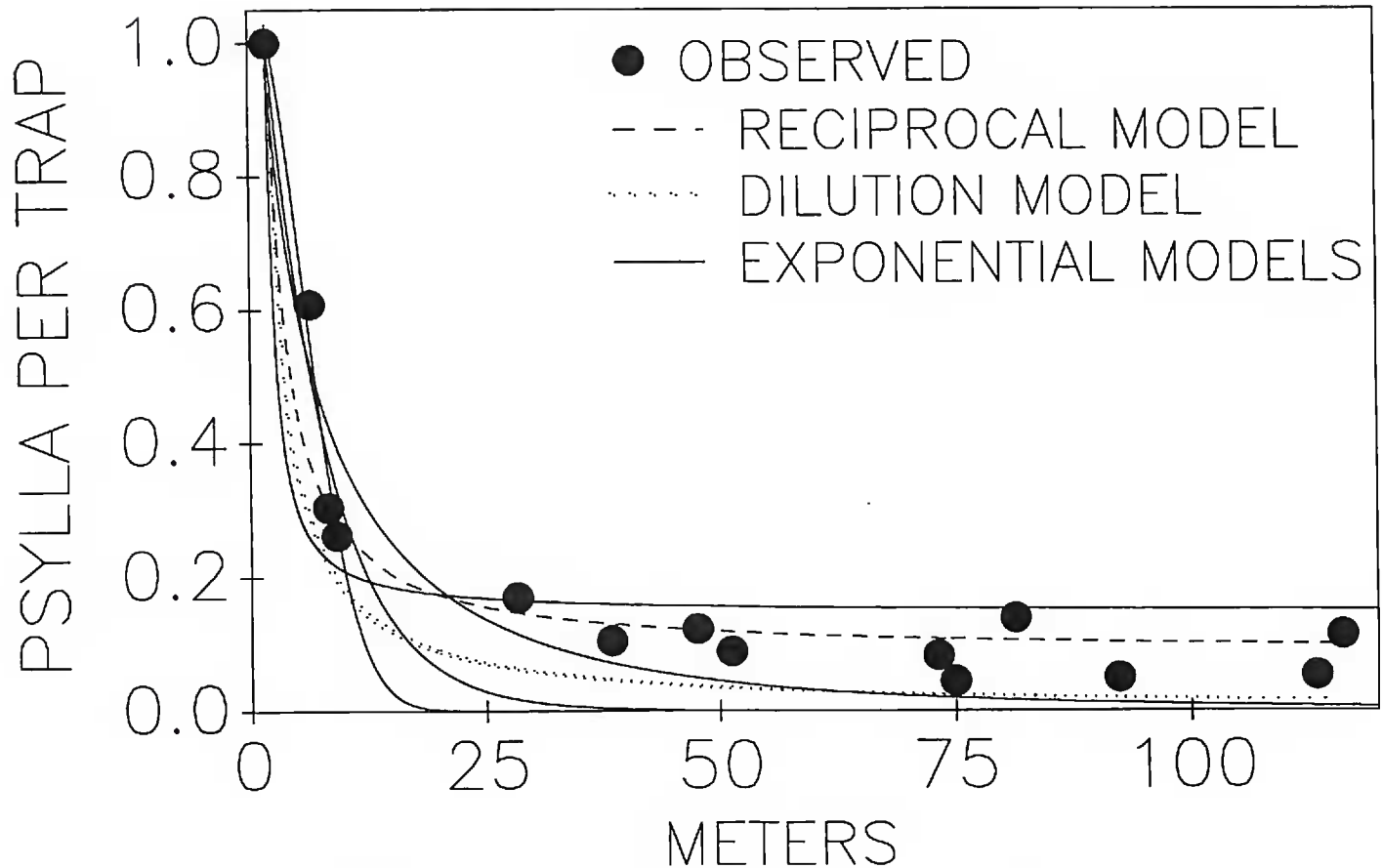


Figure 2. Example of relationship between trap catch (expressed as fraction of catch on the 1.8 m trap) and trap distance; Oct. 19–31, 1990 winterforms. For the exponential models:  $c = 2$  (curve intersects X-axis at  $< 25$  m);  $c = 1$  (curve intersects X-axis between 25 and 50 m);  $c = 0.5$  (curve intersects X-axis at 100 m);  $c = -1$  (curve fails to intersect X-axis). See Table 1 for regression statistics.

smaller for the summerform curve than the average winterform curve (single df contrast:  $F = 5.8$ ;  $df = 1,57$ ;  $P = 0.019$ ), indicating that trap catch at longer distances was larger for winterforms than summerforms. However, this difference was apparently due to the 15 Nov–17 Dec 1990 winterform sample (Fig. 3, bottom panel); deletion of this sample resulted in a non-significant contrast ( $F = 1.99$ ,  $P = 0.16$ ). The mean distance dispersed by trapped summerforms fell within the range of means exhibited by dispersing winterforms (Table 2).

Sex ratio of trapped psylla was more female-biased for summerforms than winterforms (Fig. 6; mean [SEM] percent female, summerforms—61.2% [2.5];

Table 2. Estimated relative frequency of psylla in each of four distance classes and mean distance dispersed by trapped psylla.

Sampling interval	Distance class (meters)				Mean distance (SD) <sup>a</sup>
	0–30	30–60	60–90	90–120	
Winterforms					
19–31 Oct. 1990	0.27	0.18	0.26	0.29	62.1 (34.9)
1–14 Nov. 1990	0.29	0.21	0.23	0.26	58.4 (34.7)
15 Nov.–17 Dec. 1990	0.16	0.20	0.32	0.33	70.1 (31.8)
11 Sept.–6 Nov. 1991	0.12	0.05	0.48	0.35	76.8 (31.7)
Summerforms					
9 May–11 Sept. 1991	0.23	0.17	0.32	0.27	63.5 (33.4)

<sup>a</sup> See Materials and Methods (from Fletcher 1974) for calculations.

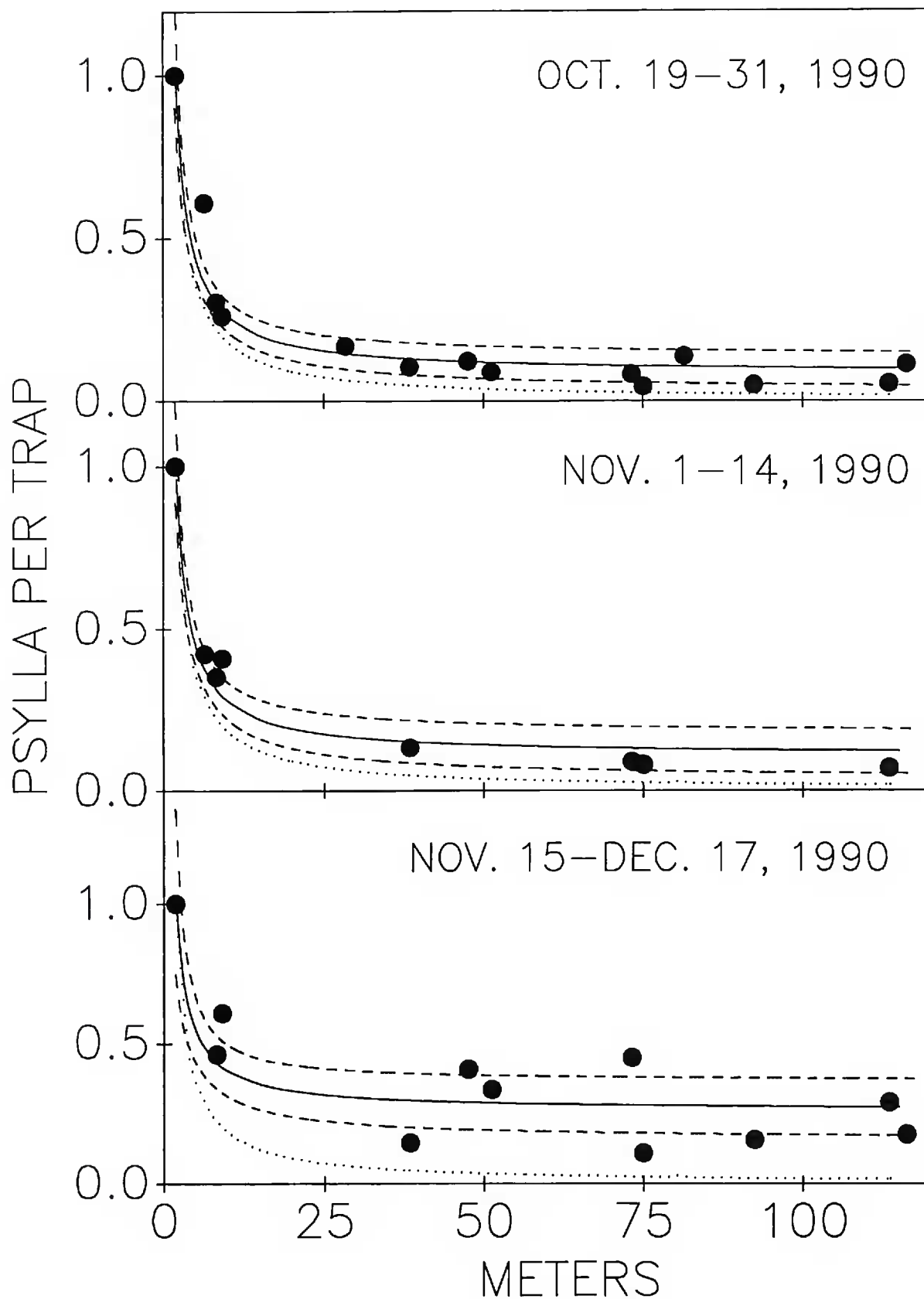


Figure 3. Observed (filled circles) and regression models (solid lines) describing relationship between twenty-four hour trap catch of fall winterforms and trap distance (1990 data); catch expressed as fraction of maximum catch (maximum catch always occurred on the 1.8 m trap). Dashed lines—95% confidence bands. Dotted lines—dilution curve. Regression summaries (see also Table 1)—Oct. 19–31, 1990: trap catch =  $0.083 + 1.79(1/\text{meters})$ ;  $r^2 = 0.92$ . Nov. 1–14, 1990: trap catch =  $0.107 + 1.71(1/\text{meters})$ ;  $r^2 = 0.96$ . Nov. 15–Dec. 17, 1990: trap catch =  $0.261 + 1.43(1/\text{meters})$ ;  $r^2 = 0.76$ . To express catch as psylla per day, multiply observed values or both regression coefficients (for prediction) by numbers captured per day on the 1.8 m trap: Oct. 19–31, 37.3 psylla/day; Nov. 1–14, 104.8 psylla/day; Nov. 15–Dec. 17, 7.6 psylla/day. Some points missing due to traps being blown down by strong winds.

winterforms—52.3% [1.4]; paired sample  $t$ -test:  $P = 0.012$  [data paired by trap location]). Sex ratio of summerforms departed significantly from 50% ( $t = 4.6$ ,  $P < 0.001$ ).

For spring colonists, the reciprocal model fit the catch data for the orchard-

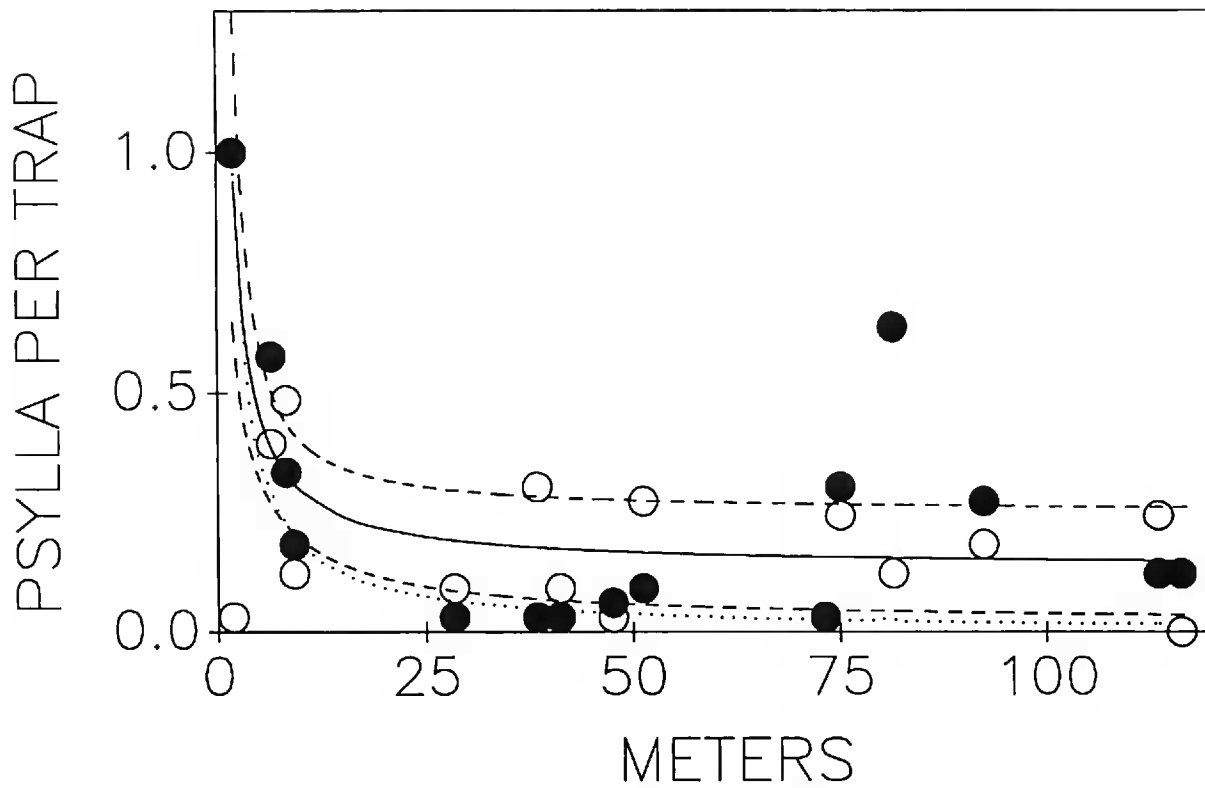


Figure 4. Observed (filled and open circles) and regression model (solid line) describing relationship between twenty-four hour trap catch of fall winterforms and trap distance (Sept. 11–Nov. 6, 1991); catch expressed as fraction of maximum catch (maximum catch always occurred on the 1.8 m trap). Solid circles, orchard-side of trap; open circles, backside of traps (regression line fitted to filled circles). Dashed lines—95% confidence bands. Dotted line—dilution curve. Regression summary (see also Table 1): trap catch =  $0.134 + 1.61(1/\text{meters})$ ;  $r^2 = 0.62$ . To express catch as psylla per day, multiply observed values or both regression coefficients (for prediction) by numbers captured per day on the 1.8 m trap (= 0.59 psylla/day).

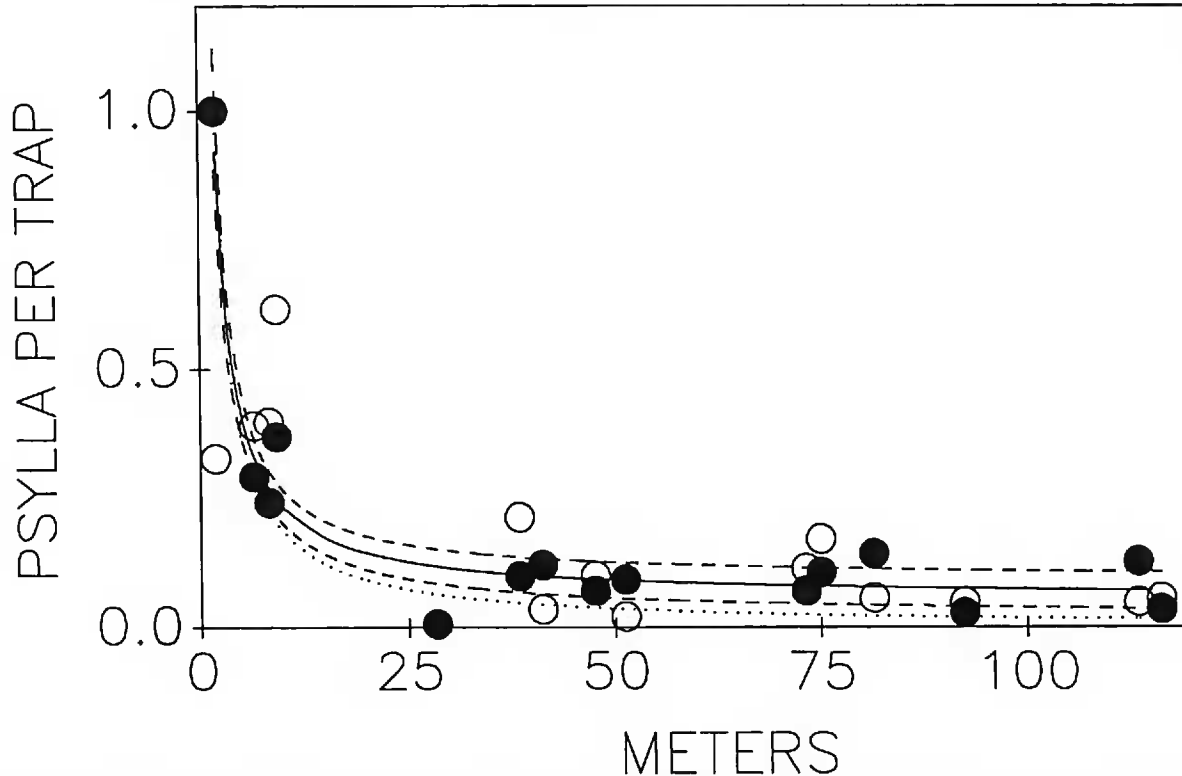


Figure 5. Observed (filled and open circles) and regression model (solid line) describing relationship between twenty-four hour trap catch of summerforms and trap distance (May 9–Sept. 11, 1991); catch expressed as fraction of maximum catch (maximum catch always occurred on the 1.8 m trap). Solid circles, orchard-side of trap; open circles, backside of traps (regression line fitted to filled circles). Dashed lines—95% confidence bands. Dotted line—dilution curve. Regression summaries (see also Table 1)—orchard-side of traps: trap catch =  $0.057 + 1.73(1/\text{meters})$ ;  $r^2 = 0.95$ ; backside of traps (regression line not shown): trap catch =  $0.34 - 0.0032(\text{meters})$ ;  $r^2 = 0.46$ . Reciprocal curve—to express catch as psylla per day, multiply observed values or both regression coefficients (for prediction) by numbers captured per day on the 1.8 m trap (= 1.13 psylla/day).



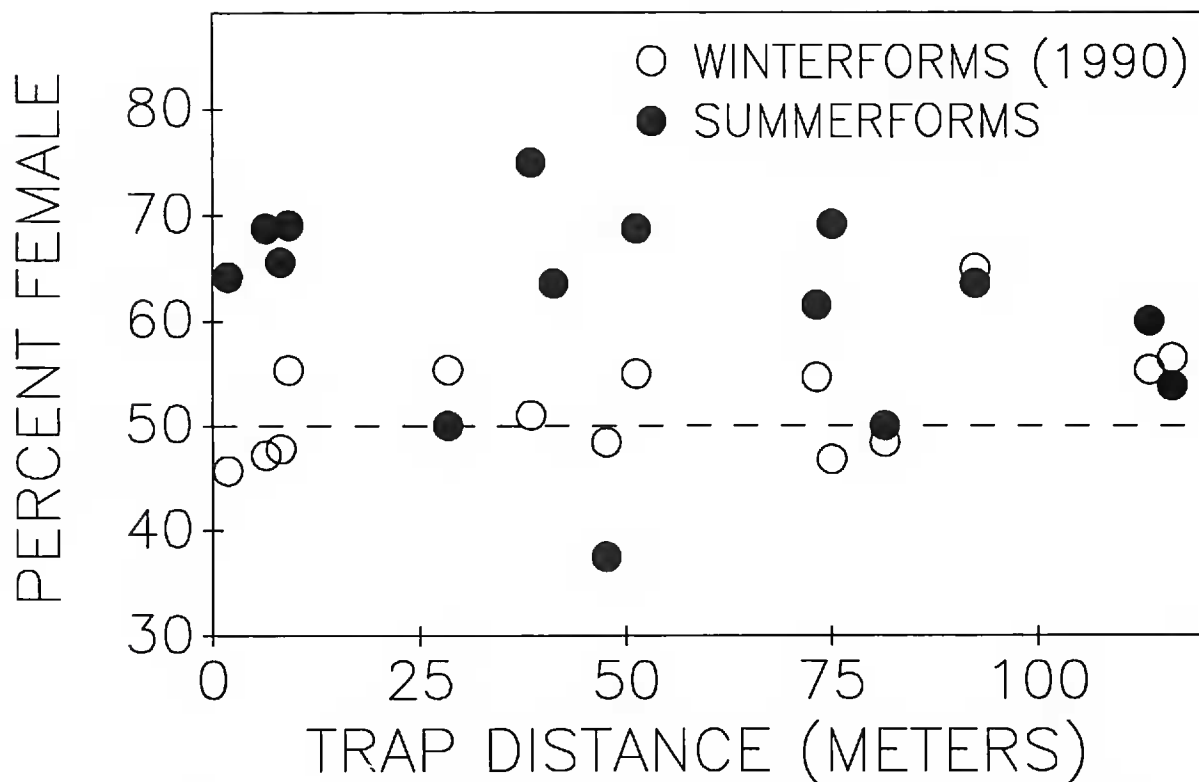


Figure 6. Sex ratio (percent female) of trapped summerforms and fall winterforms (catch summed over intervals).

side of the trap ( $P < 0.005$  for both years), whereas linear models provided better fits for the back-side catch (Fig. 7; 1991:  $P = 0.06$  [reciprocal model:  $P = 0.38$ ]; 1992:  $P = 0.03$  [reciprocal model:  $P = 0.06$ ]). Capture rates were the same on the orchard-side and back-side of traps both years (paired sample  $t$ -tests;  $P > 0.50$ ).

There were no significant direction effects within any of the five samples for emigrating psylla (Fig. 8; each by one-way ANOVA [although  $P = 0.07$  for the 1990b sample]). There were significant direction effects for both the 1991 ( $P = 0.03$ ; orchard-side) and 1992 ( $P = 0.02$ ; orchard-side) spring reentry data (Fig. 9). Traps running to the south caught more psylla than those in other directions. The pear orchard nearest the study area was directly in line with the traps running to the south (approximately 1 km south of the study area), and this may partially explain these patterns.

#### DISCUSSION

Trap catch-distance curves for emigrating winterform and summerform pear psylla were very similar to curves reported for other insect species (e.g., Wadley 1957). Counts were high near the source orchard, rapidly decayed between 5 and 20 meters, and then flattened out over the longer distances. The flattest curve was for late-fall winterforms in 1990 (Fig. 3, bottom panel; see Table 2 for mean distances dispersed by trapped psylla, calculated from observed values). Purcell & Suslow (1984) noted that catch-distance curves obtained from beat tray samples in peach orchards markedly flattened out late in fall, and interpreted this as evidence that psylla dispersed from the orchard in a wave-like pattern over a protracted period of time. Thus, in our study, psylla that were captured at the longer distance traps in December probably included insects that had temporarily occupied the non-pear habitat surrounding the traps, whereas trap catch earlier in the dispersal period (i.e., October) likely was composed primarily of insects that had originated in the orchard.

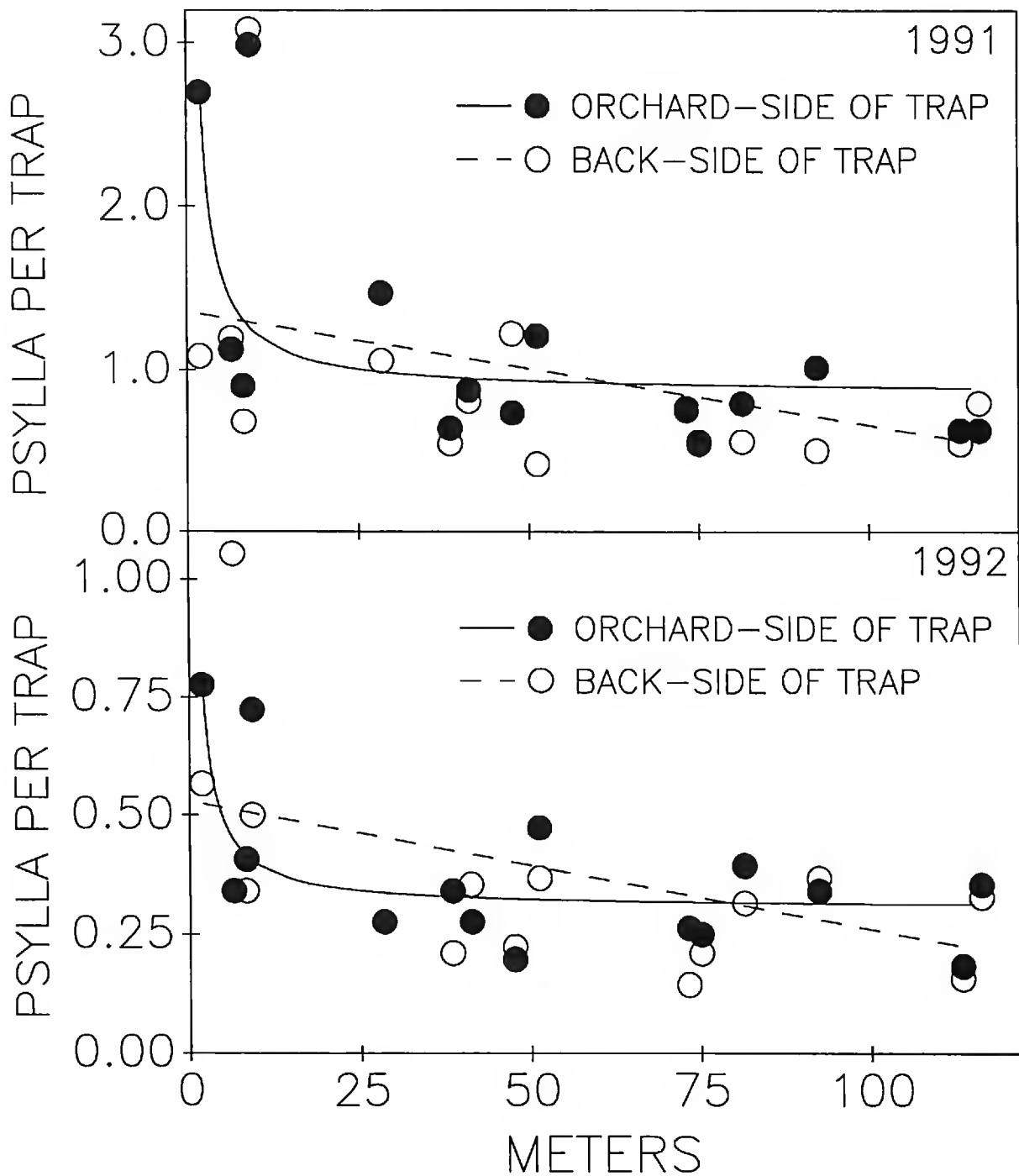


Figure 7. Observed (filled and open circles) and regression models (dashed and solid lines) describing relationship between twenty four hour trap catch of spring winterforms and trap distance (Feb. 22–May 9, 1991; Jan. 28–April 10, 1992). 1991, orchard-side of trap: twenty-four hour trap catch =  $0.81 + 3.47(1/\text{meters})$ ;  $r^2 = 0.47$ ,  $P = 0.005$ . 1991, back-side of trap: twenty-four hour trap catch =  $1.28 - 0.0079 (\text{meters})$ ;  $r^2 = 0.24$ ,  $P = 0.06$ . 1992, orchard-side of trap: twenty-four hour trap catch =  $0.32 + 0.96(1/\text{meters})$ ;  $r^2 = 0.54$ ,  $P = 0.002$ . 1992, back-side of trap: twenty-four hour trap catch =  $0.56 - 0.0034 (\text{meters})$ ;  $r^2 = 0.30$ ,  $P = 0.03$ .

Based on residual mean squares, the reciprocal model consistently described trap data better than did any of the four exponential models. The models provide strictly empirical descriptions of the relationship between distance and trap catch, and biological interpretations are speculative. The exponential model with  $c = 2$  is consistent with a diffusive or random dispersal process (Taylor 1978, Rudd & Gandour 1984). This model did not fit observations (Fig. 2, Table 1). A “dilution” model, which assumes that size of trap catch is due entirely to the change in sampling area associated with an increase in distance from a point source (e.g., Wadley 1957, Rudd & Gandour 1984) also fit poorly (Figs. 3–5). One explanation for the poor fits of both models, particularly at the longer distances, is that traps

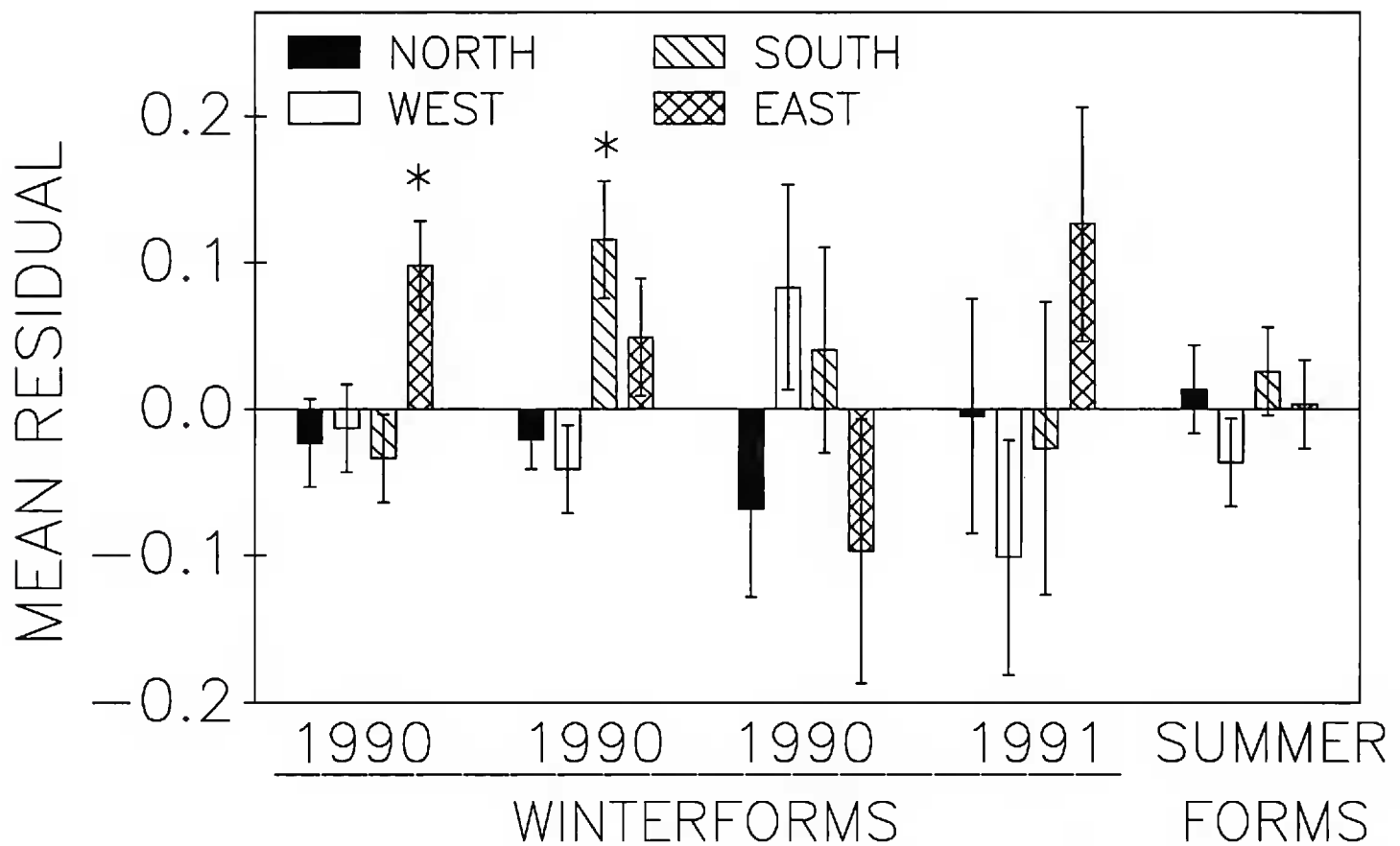


Figure 8. Mean (SEM) residual for each compass direction, fall winterforms and summerforms; regression equations (reciprocal model) summarized in Table 1 and Figs. 3–5. 1990a, 1990b, 1990c refer to Oct. 19–31, Nov. 1–14, and Nov. 15–Dec. 17, respectively (Figure 3). Orchard-side of traps only. Asterisks indicate that the mean differed significantly from zero (*t*-test). Positive values indicate that catch for a given direction was larger than predicted by the regression model.

were visible to dispersing psylla. Because the traps were placed in rangeland, alfalfa, and fallow farmland, posts supporting the traps were easily the most prominent landmark in the trapping area and may have been visible to psylla. Counts of fall winterforms and summerforms were as large on the back-side of traps as on the orchard-side of traps (Figs. 4–5), suggesting both that dispersal was not highly directional (i.e., net movement had both forward and backward components) and also that psylla were attracted to traps.

Summerforms were readily caught on traps at all distances, and the relationship between trap catch and trap distance was similar in shape to that for winterforms (Fig. 5). It still is not clear from this study or from the literature just how dispersive the summerform morph is. Some studies suggest that very few summerforms leave pear (Fye 1983, Purcell & Suslow 1984), whereas other studies have shown that summerforms are readily caught outside the pear orchard (Fye 1983, Hodgson & Mustafa 1984). The most important factor affecting numbers of summerforms leaving the pear orchard appears to be psylla density. High densities prompt movement out of the orchard (Fye 1983). In this study, summerform densities in the source orchard were fairly high, although not atypically so (maximum beating tray counts for summerforms were 35 psylla per tray, June 1991; DRH, unpublished data); maximum counts for fall winterforms were about three times as high as counts of summerforms (90 winterforms per tray were noted in October 1990 at the source orchard; DRH, unpublished data).

We cannot determine from this study whether the longer winged winterform morph dispersed longer distances than did the summerform morph. Mean dis-

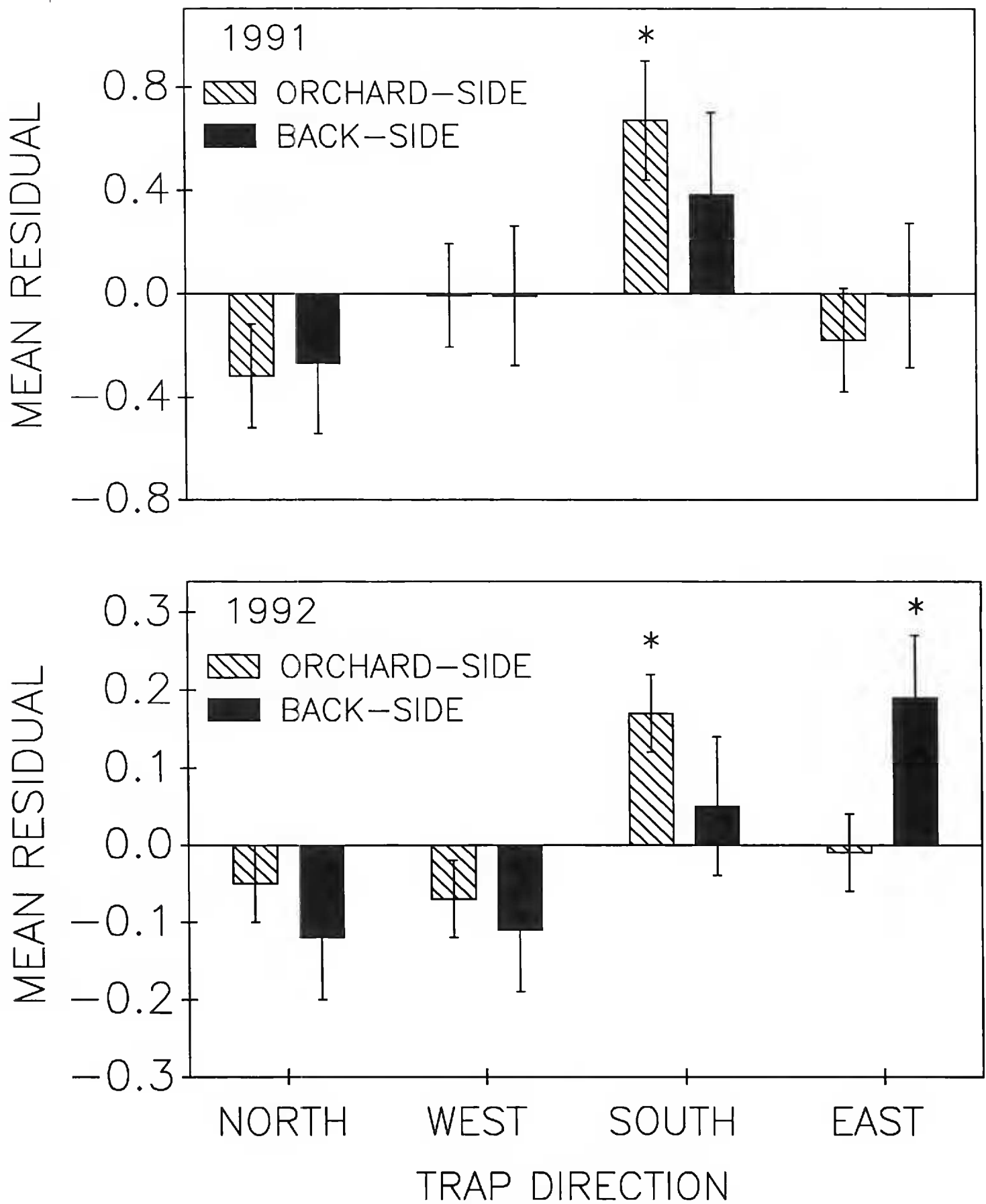


Figure 9. Mean (SEM) residual for each compass direction, spring (reentry) winterforms; regression equations summarized in Fig. 7 (reciprocal model for orchard-side of traps, linear model for back-side of traps). Asterisks indicate that the mean differed significantly from zero (*t*-test). Positive values indicate that catch for a given direction was larger than predicted by the regression model.

tances travelled by captured psylla were similar between morphs (Table 2), although results in Table 2 refer only to psylla within the study area. One difference between morphs that we did note is that trapped summerforms were more likely to be female than male (Fig. 6; also noted by Westgard & Madsen 1963), whereas winterform sex ratios were not different from 1:1 (Fig. 6). Whether this bias for

summerforms was due to a sex ratio bias in the source orchard (Westigard & Madsen 1963) or a tendency for female summerforms to be more dispersive than males is not known.

In summary, results of this study suggest that there was some movement out of the pear orchard by psylla all year. We were unable to demonstrate any strong directional component for emigrating psylla (wind direction in the study area was highly variable day-to-day). Also, if psylla were attracted to traps, the catch-distance curves reported here will overestimate dispersal rates predicted by diffusion models (Fig. 2). Until a completely passive trap for pear psylla is developed, attempts to model psylla dispersal using techniques and models reported here should anticipate this problem.

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